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Damage and Recovery In Deciduous Orchard Trees From Major Freezes

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SUMMARY

Major freezes that inflict costly damage on trees pose exceptionally difficult problems for growers of deciduous fruit and nut crops. These severe freezes can be predicted only to this extent: They may be expected to recur as infrequent emergencies in this country in most of the areas adapted to the deciduous orchard industries.

This report summarizes some information likely to be useful in dealing with the unusual damage in trees caused by severe freezes and tree recovery. Three conditions are discussed: damage from freezing in autumn before trees are fully hardened; in winter when trees are dormant; in spring after trees are advanced in seasonal growth.

Freeze damage, though varied, has shown some significant patterns that appear to be characteristic. For example, a late autumn or midwinter freeze may be expected to do worst damage to tree trunks and older wood; a late spring freeze to smaller wood and new growth.

One outstanding lesson has been repeatedly demonstrated: avoid hasty efforts to treat the trees. Immediately after a freeze, it is generally impossible to tell how badly the trees are injured. Weeks may elapse before surviving trees start to show natural recovery. Allowed time, some trees that looked hopeless have been known to survive and be well worth saving. In any case, as the outcome becomes clearer the appropriate treatments for damaged orchards can be planned and applied on a sounder basis.

DAMAGE AND RECOVERY IN DECIDUOUS ORCHARD TREES FROM MAJOR FREEZES

Major freezes that inflict costly damage on trees pose exceptionally difficult problems for growers of apples, pecans, and other deciduous fruit and nut tree crops.

The rare hazard of a major freeze is far different from local frost due to cold that is usually only a few degrees below 32° F. Temperatures in this range may injure buds or developing fruit to the extent of wiping out a year's crop, but such cold does little damage, if any, to the trees themselves.

Major freeze damage in an orchard area occurs when an extraordinary cold wave from the Far North or Northwest brings a large mass of frigid air into an area. The cold may strike in autumn, winter, or spring. Whatever the season, if the air mass overhead becomes stationary, it can settle and cause orchard temperatures to drop so low or so suddenly that moisture in susceptible trees is frozen extensively.

Growers do not plant commercial orchards where such setbacks are common. In the span of this country's deciduous orchard industry, major freezes have occurred infrequently, though at greatly varying intervals. When a major freeze does occur in an established orchard area, many growers in the area may be unfamiliar with the kinds of damage sustained by the trees or what to expect of the future.

After any major freeze, the information most needed by growers is along lines that answer two broad and basic questions:

1. What recovery can be expected of trees damaged in various ways by freezing?
2. What measures for treating surviving trees are likely to give best ultimate results?

In past emergencies, growers in many cases have had to pioneer in restoring damaged plantings. Some growers anxious to start reconstruction have hastened to prune and treat damaged wood or even to bulldoze entire orchards and plant new trees--not realizing that early impressions of freeze damage may be misleading and that it usually pays to give the trees time to show more clearly the true state of their injuries.

In each major freeze situation, research horticulturists in the area have helped with counsel and have tried out experimental procedures for restoring damaged plantings. From their work and observations, added to the experiences of growers, information is accumulating for partial answers to the basic questions and related problems.

In recent decades when a major freeze has occurred, the damage has been reported upon in the year or years following, notably in talks or panel discussions at State horticultural society meetings. But relatively little

has been published, outside the area affected, on the actual damage and recovery of the trees or knowledge gained for dealing with similar damage.

* * *

This report brings together selected information on damage in deciduous fruit and nut trees and observations and suggestions by scientists of the Agricultural Research Service and other agencies. It includes also some background information for perspective.

The freezes selected as primary examples represent damage at 3 stages in the yearly growth and dormancy cycle of deciduous trees, specifically--

- * A freeze in late autumn (or early winter) before the trees are fully hardened--illustrated by the November 1955 freeze in the Pacific Northwest, which damaged all kinds of fruit and nut trees in Washington and northern Oregon.
- * A winter freeze in which temperatures fall so low that dormant trees are extensively killed or injured--illustrated by the severe and protracted cold (actually a series of freezes) which caused great damage to Northeast orchards in 1933-34.
- * A freeze in spring so late that new growth is advanced--illustrated by the freeze of late March 1955, which blanketed the Southeast and did costly damage to peach, pecan, and tung plantings.

ARS scientists are still observing trees that were damaged by the 1955 freezes, to gauge long-range effects of the cold.

No unusually severe midwinter freeze has occurred in the past few years in the Northeast orchard area. The 1933-34 winter freeze consequences were reviewed in the following year by New York horticulturists and growers and helpful advice was formulated. There is more detailed statistical information on the damage of this freeze than of any other severe midwinter freeze. This information was obtained from surveys made by the USDA and New York agricultural statisticians.

TREES AND LOW TEMPERATURES

Cold Requirements

All of the hardy and semi-hardy deciduous fruit and nut trees require some winter cold to break their dormancy to produce a crop. Buds do not open normally in spring if these trees have not been exposed to adequate amounts of cold below 45° F. during dormancy, such as:

Apples: about 900 to 1,200 hours.

Peaches: commonly grown varieties, about 700 to 1,000 hours.

Pears: varieties of European origin, about 700 to 1,000 hours.

Pecans: about 500 to 800 hours.

Tung: 350 to 400 hours.

Walnuts: some varieties of Persian (English) type, about as much cold as peaches; others as much as apples, or even more.

Cold requirements of deciduous trees determine southerly limits for favorable crop production. Fruits and nuts requiring 700 hours or more of cold are little grown within 150 miles of the Gulf coast and comparable localities.

Limits of Cold Resistance

Because the deciduous orchard crops require some winter cold, the risk of excessive cold cannot be entirely avoided. Weatherwise growers plant within the climate areas where crops can be produced without undue risk of frosts or heavier freezes.

The kinds of fruits and nuts that are commercially planted differ widely in resistance to cold, and a good deal is known about their tolerance in an established orchard area. Certain varieties of each kind of fruit are recognized as being hardier and more resistant to winter cold damage than others. Varieties tolerant to low winter temperatures are in general also resistant to autumn cold. These varieties, however, may not be especially tolerant to spring frosts which injure blossoms. The following general information may give some idea of amounts of cold that deciduous orchard trees normally stand without serious damage at different stages of their yearly cycle:

In autumn, as the trees shed foliage and become dormant, they progressively harden and tolerate increasing cold. Unseasonable cold in this transition stage--such as 0° F. in northern areas in November--may be much more destructive than -20° F. would be after Christmas.

In midwinter when trees are fully dormant, the minimum temperatures that most varieties may be expected to tolerate in northern areas are about as follows:

Apples, sour cherries, American plums: -20° to -30° F.

Pears, sweet cherries, Japanese and European plums: -15° F.

Peaches, apricots: -10° to -15° F.

Filberts of European varieties and Persian (English) walnuts: -10° to -15° F.

In spring, in all areas during the active growth stage, deciduous fruit and nut trees are severely damaged if temperatures drop into the low 20°'s. Succulent new growth in nearly all such trees is injured by temperatures around 24° or 25° F. Some kinds, such as tung, may be injured by even less cold.

A general relationship exists between the prevailing minimum temperatures--those average or normal for a locality--and the temperatures that deciduous trees in the locality will stand without damage.

Figures 1 to 3 diagram this relationship for peach and apple trees in several fruit growing localities. In these examples, the tolerance range--the temperatures the trees will stand without serious injury--is roughly parallel to the mean minimum temperatures that prevail in an area. From fall to mid-winter the trees adjust to increasing cold. As temperatures moderate toward spring, temperatures likely to damage trees also become higher.

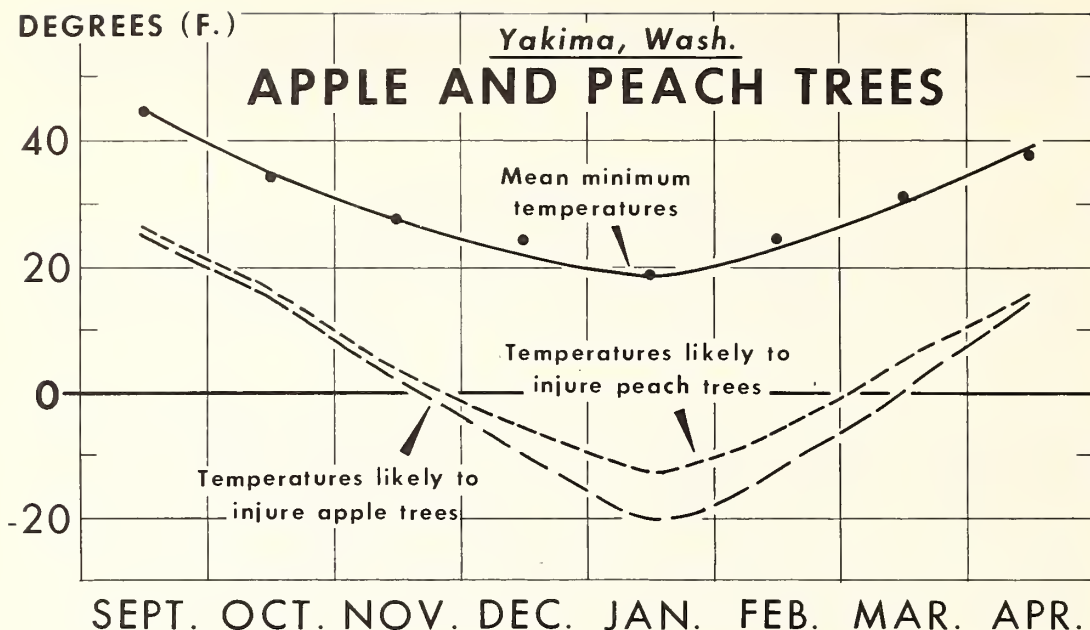


Figure 1.--Mean minimum temperatures at Yakima, Wash., and the temperatures that may be expected to injure peach and apple trees.

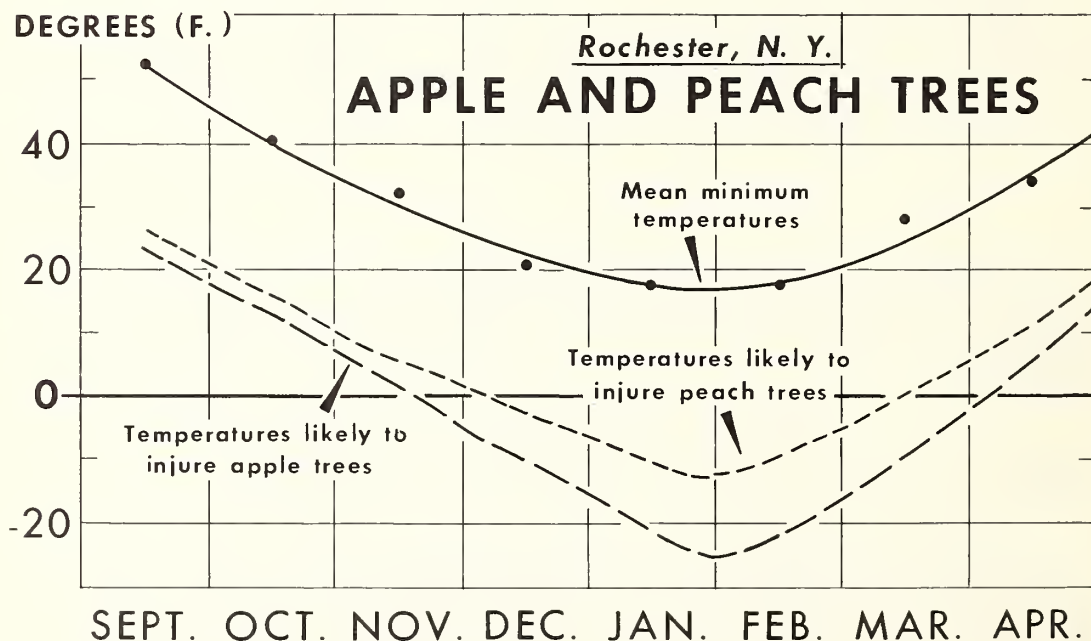


Figure 2.--Mean minimum temperatures at Rochester, N. Y., and the temperatures that may be expected to injure peach and apple trees.

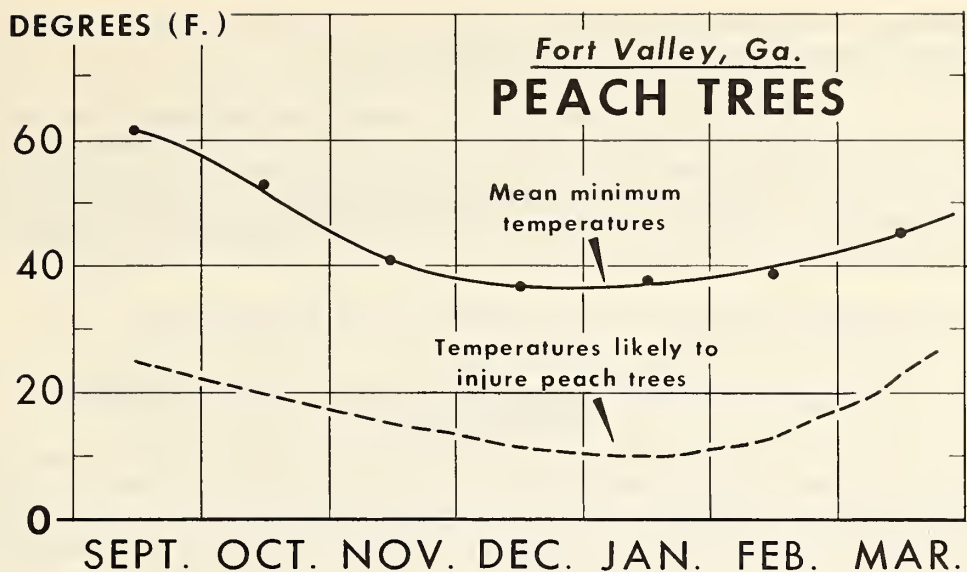


Figure 3.--Mean minimum temperatures at Fort Valley, Ga., and the temperatures that may be expected to injure peach trees.

The rate of onset of the cold and its duration may alter the normal expectancy of how much cold trees can stand. Tolerance is less if a temperature drop is rapid. Prolonged cold also lessens tree resistance and increases the amount of injury.

The Freezing Process

When cold is sharp enough to freeze sap in a tree, the ice crystals do not generally form inside living cells. Rather, water from the cells moves to spaces between the cells, and here the ice crystals form.

The more succulent the tissue and the higher the moisture content, the more prone the tissue is to injury. Expansion and pressure of frozen moisture may split wood and bark. Often the bark is separated from the wood. The exact mechanics of the death of cells from freezing still are not fully known.

If living cells are not permanently altered in physical or chemical structure by the ice formation, the cells can refill with moisture and resume normal activity when the ice thaws. However, cells killed become discolored. In this connection, it has been emphasized that a browned look of normally green tissue in the cambium and inner bark areas of a tree limb or trunk does not necessarily mean that the whole tissue is dead. The damaged tissue may contain uninjured cells in sufficient number for these to restore normal activity to that part of the tree.

Tree Parts Most Susceptible

The part of a tree most susceptible to freeze damage in late fall and winter is generally the collar or crown, just above ground line. This trunk area--unless protected by snow cover--also bears the brunt of frigid air, which tends to be coldest at ground surface. Collar bark is often killed by

temperatures that cause no other structural damage. Tree crotches are also particularly sensitive to excessive cold.

Roots are the tenderest part of a dormant tree. Roots of fruit and nut trees will be injured if their temperatures are reduced to below 20° F. Actually, the soil protects roots so well that they are injured less often than the tops of trees. Root injuries may be severe, however, when prolonged sub-zero temperatures occur without snow cover, especially in light textured soils.

The tenderest part of a tree in spring is its new growth.

THE LATE AUTUMN FREEZE OF 1955 IN THE PACIFIC NORTHWEST

The freeze of November 1955 was the third in half a century to cause serious damage to Pacific Northwest orchards in late fall or early winter. Somewhat similar freezes occurred in 1935 around the first of November and in 1919 near mid-December.¹

The following account of the November 1955 freeze includes observations in 1958 by ARS scientists at field stations in Washington and Oregon.

The Weather

The growing season was late in Pacific Northwest orchards prior to the November 1955 freeze. Frosts were late in many localities. Average temperatures around Walla Walla, Wash., were near normal in the week preceding November 11 and orchards were in full leaf.

On November 11, a cold air mass from the Arctic moved over Washington and spread southward. For about a week many orchard districts in Washington and northern Oregon had temperatures low enough to break records for this early in the season. On November 15, the critical date, typical official minimums were: In Washington, 3° F. at Wenatchee, 0° F. at Prosser, -3° F. at Yakima, -4° F. at Walla Walla; in Oregon, -2° F. at Hood River and at Milton Freewater. Orchard temperatures were undoubtedly below the official minimums in many cases.

In February 1956, minimum temperatures in the range of -10° to -20° F. occurred and appeared to cause further damage to trees already injured. Such temperatures in February would not be expected to cause damage to trees not previously injured.

Tree Damage

The most characteristic and serious injury caused by the November freeze was trunk damage at crotches and the collar area, especially on

¹ Among the late autumn freezes in other areas, one especially memorable is the Armistice Day freeze of 1940 that blanketed a large part of the Midwest, including orchard districts. On November 10, some apple orchards were in full leaf and fruit was being picked. On November 11, a blizzard swept in with high wind, snow, and severe cold. In Iowa and northwest Missouri temperatures reached zero or a few degrees below. In some Missouri counties, the freeze killed or injured about three-fourths of the apple and pear trees and killed nearly all peach, cherry, and plum trees. Loss was even greater in Iowa. Trunks and large limbs were outstandingly damaged--a characteristic effect of this kind of freeze. Some damage from this freeze occurred even in the Gulf States, where young tung trees were killed to the ground.

young trees. Many trees were girdled, presumably because the cambium layer between wood and bark still contained much moisture. The more vigorous and active the tree, the more moisture it contains and therefore the more vulnerable to a freeze at this season.

By tree age, the worst damage in general from this freeze was in young trees 2 to 12 years old, and particularly the 4 to 8 year old group. In the case of sweet cherries and Japanese plums, trees of all ages were severely damaged throughout the fruit growing areas.

It has been common in major freezes for trees in the same locality to show marked variations in freeze damage. Orchards favorably located for air drainage were more damaged in this Northwest freeze than those where drainage was poor, because the latter had been previously subjected to more cold and were partly hardened. Orchards in high altitudes and exposed to the northern wind were more injured than those better protected. The susceptibility of vigorous, active trees has been mentioned, and there was evidence that their susceptibility was increased by any treatment that delayed hardening, such as late season cultivation, fertilization, or watering. For example, orchards were more seriously injured where irrigation had been continued until relatively late.

Among the kinds of fruit trees, Japanese plums were practically wiped out in this freeze. Sweet cherry trees ranked second in damage. Apple trees ranked third, with losses figured variously at 20 to 40 percent in trees under 10 years old. Older apple trees were little damaged except in the spur buds. Enough spur damage occurred to reduce the crop in 1956 by about 25 percent. Of the European plums, only the prune types were badly injured. Peach trees were hurt surprisingly little.

Some varietal differences in resistance to a freeze at this season were observed. Among the sweet cherries, Van showed outstanding resistance, followed by Black Republican, Sam, Lambert, Ebony. The worst damaged sweet cherries were Bing, Royal Ann (Napoleon), and Tartarian. Among pears, Bartlett trees were injured much more than Anjou. The regular Italian prune was injured somewhat less than its early ripening strains. The Elberta, J. H. Hale and Red Haven peach varieties had serious trunk and framework damage, especially in orchards with minimum "pre-conditioning" cold. Good resistance was shown by the apricot varieties Earliril, Riland, Sun-Glo, Stella, J. L. Budd, Perfection, Phelps, Manchu.

Apple varieties showed no clear-cut differences with the possible exception of Jonathan, which was more severely injured than Winesap, Delicious, or Golden Delicious. Unexpectedly, the relatively hardy McIntosh showed as much injury as Delicious. Trees on Hibernial understocks remained undamaged.

In nut orchards, walnuts were much worse damaged than filberts. In some hillside plantings exposed to northeast wind in the northern Willamette Valley of Oregon, many walnut trees were killed outright and others set back at least 10 years in production. In filbert orchards in the same area, there was little bark splitting and practically no permanent damage. In the Puget Sound district of Washington, however, Barcelona filberts were killed and DuChilly were damaged back to the main trunk. Noonsack, Alpha, and Royal varieties showed no appreciable damage other than a minor reduction in the 1956 crop.

Aftermath Trends

An extraordinary aspect of this type of freeze is that the damage may be worse than first impressions indicate. Damage from the November 1955 freeze has exceeded early expectations. The same was true in 1919. After the 1955 autumn freeze, many trees that were girdled at the base died in 1956 and 1957. Walnut trees particularly sustained much structural injury that showed up when a crop was set in 1957. Laden branches showed their weakness by breaking out at the crotches.

However, many trees that survived the 1955 freeze have shown good natural recovery and no signs of weakness. Sweet cherry trees, for instance, were badly damaged, yet some partly girdled trees produced enough vigorous growth in 1956 to replace from a third to almost all of their original bearing surface. Some almost entirely girdled produced overgrowth of new tissue in trunk and crotch areas and have borne good cherry crops since the freeze. Many cherry trees that lost most of their small wood produced profuse growth along the leaders and began bearing fairly good crops in 1957.

Suggestions to Growers

ARS scientists have suggested the following precautionary measures and some remedial procedures for dealing with late autumn freeze damage:

Curtail late-season cultivation, fertilization, watering, or any other treatment that prolongs active growth of trees past their normal time of hardening. Such late-season treatments increase the risk of tree injury from a freeze in autumn.

If it becomes evident that bark is killed at the ground line, but trunk tissues above are sound, bridge grafting--particularly of younger trees--will generally be successful. Bridge grafting needs to be done as soon as practical the following spring. Bridge grafting after the November 1955 freeze was generally--though not always--successful in saving trees over 5 years old when the grafts were properly made. Results of bridge grafts may not be quickly known. Many successful grafts did not show their beneficial effects for about a year. Although bridge grafting may save a completely girdled tree, planting a new tree may be preferable to provide a tree without injury.

A practice that has given good results on trees not over 4 years old is to allow sprouts to develop from the base of girdled trees. The strongest one of these is trained to form a new top. The old top and other sprouts are removed when the selection is made. If the sprout selected grows from below the bud union, it must be grafted or budded to the variety.

In dealing with stone tree fruits some measures that appear satisfactory have been suggested by ARS and State scientists at the Irrigation Experiment Station in Prosser, Wash.:

Sweet cherry trees have responded best to pruning back to live wood unless the trees were so far gone that pruning would wreck the tree. Since the immediate objective is to regain as much leaf surface as possible, all new growth should be retained temporarily. Trees thus treated after the 1955 freeze put out bushy growth that required corrective pruning in 1958 but the structural wood that was salvaged enabled many trees to bear some fruit in 1956 and 1957.

Sour cherry, peach, apricot, and prune trees--kinds less severely injured than sweet cherry--responded best to normal pruning and management.

Where bark and wood of trunks separated, it has appeared helpful to tack back the bark to protect live cambium. Use of a protective paint over open splits appeared helpful, though not essential.

Control of shot-hole borer is a likely necessity as a follow-up measure in stone fruit orchards.

THE WINTER FREEZE OF 1933-34 IN THE NORTHEAST

The Northeast freeze of 1933-34 was actually a series of freezes. The cold caused cumulative damage on dormant trees by occurring repeatedly, severely, and at times suddenly. Fruit trees killed or injured that winter totaled millions. The greatest damage centered in fruit belts of western and northern New York, though the damaged orchards ranged from Michigan to New England. A New York fruit specialist who compared the damage with that of 1917-18, rated the winter of 1933-34 as more destructive.

Some winter injury occurs fairly often in northerly orchards and much has been written about it. However, when tree damage is as severe and extensive as in 1933-34, the leading characteristics and effects may be unfamiliar to many of the growers concerned. The following account of the freeze is necessarily limited. Problems and helpful measures were reported, notably in proceedings of the New York State Horticultural Society.

The Weather

The recurring cold waves of the 1933-34 winter were alternated with moderate or even mild weather from November onward. In many localities, the severest night of the winter was experienced on February 9. In western New York, for example, Brockport that night recorded -25° F.; Lockport, -24° F.; Rochester, -22° F. Farther northeast, Watertown, N. Y., recorded -27° F. on February 9, but had already had its coldest night on December 29 when the temperature fell to -39° F. Drought conditions which preceded and followed this hard winter imposed additional strain on the trees, especially in western New York.

An Unusual Survey of Freeze Damage

An effort to survey the damage was made cooperatively by agricultural statisticians of the U.S. Department of Agriculture and New York State during the summer after this freeze. Questionnaires were sent to fruit and crop reporters, asking for their expressed judgments on the extent of the freeze damage in their localities. Returns were compared with figures on total plantings as reported in the 1930 United States Census and the 1932 survey of tree varieties and ages. Here are some statistics from the survey and a few supplementary observations:

- * In New York State, where the damage was greatest, out of more than 16,000,000 fruit trees of all ages, 2,500,000 were killed and 3,800,000 injured.

- * As in most major freezes, the damage varied even in the same localities, but showed some characteristic patterns of greater or less damage in trees of certain kinds and varieties, ages, and environmental conditions.
- * This freeze was most destructive to trees in the prime of bearing or older. Although the statistics did not break down age figures beyond bearing and nonbearing, the reports indicated that mature and productive trees with large bearing surfaces were especially susceptible to this freeze. The cold tended to kill such trees outright. Trees that had borne a heavy crop the preceding fall were in general much more severely injured than trees that bore a light crop or none. Also, trees pruned before the freeze were much more severely injured than trees that had not been pruned. Another large group of dead or damaged trees--in fact, a tremendous proportion--were practically valueless prior to the freeze from age or neglect. Properly these trees should have been removed in any case. In New York, about 1,000,000 of the dead or injured trees of bearing age were in this class.
- * Apple tree damage was the largest. New York reports indicated that out of 10,000,000 apple trees, 1,458,000 were killed and 2,335,000 injured.
- * The following percentages of apple trees were estimated to be dead or likely to die from the winter freeze: 44 percent in Maine, 13 percent in New Hampshire, 10 percent in Vermont, 7 percent in Rhode Island, 6 percent in Connecticut, 4 percent in Massachusetts. In Michigan, the loss of apple trees of bearing age was reported at 5 to 10 percent, and mainly in the less favorable fruit growing districts.
- * The Baldwin apple, which had been a mainstay in building the northeastern fruit industry, was on the wane and lost further prestige by showing more damage from the freeze than any other major apple variety. The survey indicated that 72 percent of Baldwins in Maine were dead or expected to die; 50 percent in Vermont; 22 percent in New Hampshire. Many additional trees proved badly injured. In New York, the cold killed 27 percent of Baldwins of bearing age and injured 36 percent.
- * The naturally hardy McIntosh apple, which was rising in favor, showed strong resistance to the freeze. In New York, fewer than 2 percent of McIntosh trees were killed and less than 6 percent injured.
- * Peach trees ranked second to apples in damage in New York fruit belts. More than a third of the peach trees of bearing age were killed and another third injured.
- * Other kinds of fruit showed lesser damage. In New York, about 9 percent of the pear trees of bearing age were killed and 21 percent injured. The lesser damage to pears than to apples, however, probably was because most pear orchards were near Lake Ontario, and were exposed to less severe cold than many of the apples. Sweet cherries were more damaged than sour cherries, and plums more than prunes.

Determining Trees Worth Saving

Clearing out wreckage and rebuilding orchards involved immense labor after this freeze. A common problem for several years was deciding which trees to save among those badly injured. In January 1935, a Cornell University fruit specialist described several indicators which growers might look for, when in doubt as to whether a surviving tree was likely to prove an asset or a liability. His suggestions were along these lines:

Foliage production in the summer following the freeze was one important indicator of prospective recovery. Trees that had lower branches killed were worth saving provided a portion of the top was comparatively unhurt. As a rough guide, a tree worth saving should have at least half of the top in fairly good condition, and furthermore the potential bearing surface should be low enough for satisfactory management--that is, not more than 10 or 15 feet from the ground. In another group were trees that showed scattered foliage throughout, but the leaves were small and not well colored. If such trees failed to put out vigorous new growth in a second year, they were not worth keeping. In still another group were trees with badly damaged surface that developed abundant sucker growth on the trunk and on branches 2 inches or more in diameter. Such trees gave some promise of building up new bearing surface in 3 or 4 years and resuming productivity.

Another indicator of recovery potential was the width of the ring of new growth formed in the season of 1934. Trees that produced good foliage generally laid down a good sapwood layer $3/16$ to nearly $1/2$ inch wide. Trees without good foliage made a narrow ring of $1/16$ inch or less. A narrow ring indicated slight chance for recovery and the tree's prospects were poor unless it made much better growth in the second growing season after the freeze.

As a third indicator of a tree's prospects, the extent of dead bark should be gauged. If the dead bark on scaffold branches extended not more than half way around, these limbs had some prospect of escaping rot. The same quantitative limit would apply to bark damage on the trunk and crotches. But if trunk bark was damaged, the distribution of the remaining live bark was important. If the killed area of bark was extensive on one side, the limbs above the roots below were likely to die, leaving the tree in poor shape. But if a number of strips of live bark provided connection between roots and top, the tree might be expected to recover.

Aiding Tree Recovery

Following up his criteria for judging tree prospects, the Cornell University scientist advised some management practices for rejuvenating trees worth saving, summarized here:

Provide the most favorable growing conditions for the injured trees, with emphasis on normal and early cultivation and on weed control up to July.

In a sod orchard, apply nitrogenous fertilizers at normal rate, and keep grass or other growth cut closely in early season when it might compete for nitrogen and water needed by the trees for new growth.

Remove dead wood. If trees lost most of their sapwood from freezing, prune lightly to conserve as much leaf surface as possible. Follow normal pruning practices in the management of hardy varieties.

If severely injured trees bloom and set fruit heavily, most of the fruit should be removed to avoid a weighty fruit crop on trees not ready for the strain.

If trees show dead bark at crotches or extensive killing of sapwood in scaffold limbs, install braces to prevent breakage, making sure that a brace will hold branches firmly and prevent swinging or twisting.

Fight fungus infection by covering pruning or other wounds with a dressing, such as Bordeaux paint.

Tack back live bark that separated from wood, if it can be done without much splitting of bark.

Remodeling Orchards

The massive destruction of the 1933-34 freeze led to extensive rebuilding of orchards. Horticulturists pointed out that the removal of unprofitable trees gave opportunities for remodeling and modernizing orchards. A new planting might be given such advantages as better soil, better spacing. Newer and more advantageous varieties might be considered--taking into account hardiness as one asset--to replace old stand-by varieties such as the Baldwin apple and the Elberta peach.

THE LATE SPRING FREEZE OF 1955 IN THE SOUTH

The Arctic cold wave that blanketed most of the South from Virginia to Texas in March 1955 caught deciduous orchards in sensitive growth stages. Almost overnight, prospects were shattered for good peach, pecan, and tung crops. But the greatest concern of growers was for the future of their trees.

The South had not experienced such a freeze since 1894. But at least three times in the nineteenth century there were similar freezes causing extensive damage to southern crops in far advanced growth.²

The 1955 freeze has reemphasized the merit of not dealing hastily with cold-damaged trees. First impressions of a freeze in late spring may be particularly misleading, because the new growth looks so stricken. The freeze of 1955 took its toll in dead and weakened trees. But in the main, the peach, pecan, and tung trees made reassuring comebacks, each in distinctive ways.

The 1955 spring freeze provided new lines of information because it was the first of its kind in the South since the deciduous orchard industries gained importance. Agriculture Research Service scientists at field stations are still observing damaged trees and noting long-term effects.

² Though earlier freezes antedate orchard industries, they give evidence of the recurrences of major-freeze weather and its damage. In 1828, a freeze on April 5-7 was described as "the most severe ever experienced so late," by an Alabama planter who recorded crop notes in his "common place book." His observations took note of tree destruction, serious in hickories. This grower recognized a freeze effect now emphasized as basic: farmers who gave plants time for natural recuperation found that this paid. In 1849, after a mild early spring, the South had a mid-April freeze that caused damage so great that one Georgia paper printed dispatches from all over the South for weeks. In 1894, a late March freeze in the South caused extensive damage to varied crop plants, including fruit. A horticulturist at the Georgia Agricultural Experiment Station wrote a review of this freeze which stressed the ever-important point of allowing for natural recovery. He said that "after the first few days things appeared worse, if possible, than at the first examination." But by May the recovery was encouraging, he said, and fears of vast loss much lessened.

The Weather

The winter preceding the March 1955 freeze was sufficiently cold for deciduous trees in most parts of the South to complete their dormancy by February 15. Warm weather then encouraged rapid growth, until the freeze struck.

The cold came in two installments. The first on March 22-23 caused light frost damage. The weather moderated briefly. Then frigid air moved in accompanied by wind--some called it a blizzard without snow. The critical cold was registered on March 26-27 in most localities. On successive nights--March 25, 26, 27--minimum temperatures changed in such fashion as this: 45° F. to 26° to 19° at Fort Valley, Ga.; 53° F. to 24° to 23° at Ruston, La.; 44° F. to 28° to 24° at Meridian, Miss. Some localities had freezing temperatures on five successive nights. The cold subsided gradually and the weather mainly favored recovery through the summer.

Peach Trees

Tree Damage and Recovery

Peach orchards through the South were in full bloom to shuck-off stage when the freeze occurred. New shoot growth was as long as 6 to 8 inches. The extent of the damage to trees was highly uncertain at first, but fairly clear by September.

The main damage of this freeze was in shoot growth and new wood. Peach varieties showed no significant differences in resistance to this freeze. Some peach trees of all ages showed damage. Actual loss of trees was primarily among those planted the preceding winter and secondarily among those that had been in orchards 1 or 2 years. Up to 90 percent of the newly set trees died in some southerly locations where growth was most advanced.

The damage in newly set trees differed greatly even in the same variety. Trees planted early in the fall or winter--and especially those debudded after growth started--usually were more seriously injured than spring planted trees. Pruning trees back when they were planted or afterward or any other practice that promoted rapid shoot development apparently made the young trees more susceptible to the freeze. Trees in orchards exposed to the northwest wind were more severely damaged than those somewhat protected.

Peach trees of all ages that survived tended to recover surprisingly well. Around Fort Valley, Ga., many showed new growing points by April 10. New white tissue was forming over discolored wood by April 16. Trees more than 3 years old appeared normal by April 29, and younger trees that had survived were recovering fast. In 1958, an examination of cross-sectional areas of trunks of peach trees of various ages showed only a fine line of discolored tissue--the tree ring of 1955--as evidence of the set-back.

Some Experimental Treatments

Limited experiments with 3 treatments for speeding peach tree recovery were undertaken at the ARS Horticultural Field Laboratory in Fort

Valley. All trees used in these tests had normal fertilization and cultivation prior to the freeze. Findings indicate that (1) applying high rates of nitrogen did not speed recovery; (2) cultivating (disk harrowing) in orchards did not speed recovery; (3) severe pruning seemed to delay, rather than speed, recovery.

Suggestions for Peach Growers

Suggestions for peach growers formulated by ARS scientists in 1955 remain the best that they can offer on the basis of present knowledge:

As in all severe freezes, it is generally best to do nothing to trees until the extent of injury can be determined. Peach tree damage looked worst about 10 days after the freeze. Peach tree damage could be tentatively appraised about a month after the freeze.

Growers can best aid injured peach trees by continuing the good orchard practices of a normal year. Dead branches and dead trees should be removed.

If trees have not been fertilized prior to the freeze, they should be given a nitrogen application as soon as they show signs of recovery.

Pecan Trees

Tree Damage and Recovery

Pecan trees start growth so late that prior to 1955 it was widely assumed that they would never be much damaged by spring cold. But the March freeze of that year caught all varieties of pecans in some stage of growth, and more than normally advanced for the date.

Although pecan trees looked stricken after this freeze, relatively few were killed or died later. The crop in 1955 was reduced to about one-fourth of normal in Georgia, but in 1956 Georgia pecan orchards yielded a record crop of 60 million pounds.

Tree recovery from the March freeze started by mid-April when varieties that were least advanced in growth began leafing out from live buds on the past season's growth. Some badly injured pecans put out new growth and then died. The less injured trees looked fairly vigorous by mid-June and some produced a light crop of nuts.

The main damage as summed by ARS scientists was in trees of 2 classes: Older trees--more than 15 years--of early-leafing varieties were severely injured, the damage extending into wood 10 years old or older. Such trees generally recovered. Among the young trees--15 years old or less--the worst injured were trees of high vigor. Up to 50 percent of the vigorous young trees were killed or severely damaged in some localities.

The leading influence on the extent of damage was the earliness of leafing or start of growth of the variety. Varieties such as Schley and Moore that leafed out earliest were worst damaged. Many of these trees were killed back to 8- and 10-year-old wood and renewed growth only on

scaffold branches. Intermediate-leafing varieties, such as Moneymaker, Mobile, Frotscher, Mahan, Van Deman, Tesche, lost only one season of wood growth generally. Late-blooming varieties, such as Stuart, Pabst, Success, and Curtis, lost little wood and developed new terminals from live buds on the previous year's growth. Some of these produced a partial crop in 1955.

Suggestions for Pecan Growers

The following suggestions outlined by ARS scientists stress giving the trees a chance for natural recovery:

The best course for pecan growers after a freeze is to do as little as possible to damaged trees.

Pruning is not likely to be needed. If done at all, pruning should be delayed until late in the following winter or early spring. Trees with dead limbs or branches gradually slough off dead wood. Most growers allowed for this after the 1955 freeze. Those who spent time and money on pruning soon after the freeze gained no advantage. Hasty pruning may have weakened trees. Injured trees need all possible foliage to make food materials and to keep the root system healthy.

If trees have had an adequate fertilization program, additional fertilizer is not advised until the usual time--in the fall or the succeeding spring. Weeds should be kept down by moderate cultivation, mowing, or grazing.

The regular spray program should be followed in pecan orchards that escape serious damage from this kind of freeze. Severely damaged trees should be sprayed only if leaf-spot disease threatens to become serious or if insects are likely to cause loss of foliage.

Tung Trees

Tree Recovery and Damage

Fully dormant tung trees can stand midwinter temperatures of 60° or 80° F., but when actively growing and loaded with young fruit, as many were in late March 1955, they are highly sensitive to cold. The low temperatures of this freeze provided an unprecedented test of tung resistance to spring cold.

For a month after the freeze, acres of tung trees seemed fatally stricken and many growers feared that all of their trees were dead. But by late summer 1955, tree loss was tentatively figured to be no more than 10 percent. And in 1958, a specialist at the U.S. Field Laboratory for Tung Investigations at Bogalusa, La., concluded that loss was probably no more than 5 percent. The actual production loss after the first year was small, since some trees that died were in orchards that lacked first rate care.

Crotch damage was common in the injured tung trees and some trees had branches killed back into 5-year wood. A good many young trees 3 to 5 years old lost large branches and showed considerable trunk injury. These young trees later developed good branches in the vacant spaces and their appearance in 1958 was good, though they may have structural weakness which could show up in excessive breakage as time goes on.

The damage to tung trees was greatest in northern localities where cold and wind velocity were greatest. In any location, the worst injured trees were those in exposed places, on north slopes, high ground, and on the fringes of orchards.

Tung varieties differed somewhat in resistance to the spring cold. McKee and Folsom seedlings showed more damage than La Crosse, Isabel, and Lampton. The latter group had passed the peak stage of susceptibility to cold in their seasonal growth. Growers were advised not to lose confidence in an otherwise satisfactory variety that did not stand this freeze well. Folsom, for example, is resistant to autumn cold--an asset that outweighs its susceptibility to a rare freeze in late spring.

Tung tree recovery started slowly, partly because of dry weather and partly because the freeze destroyed so many growing points inside terminal buds. Many trees put out lateral buds near tips of 1954 shoots by late April and these trees looked practically normal by July. Trees with badly damaged wood failed to develop these buds even by May, but were then putting out scattered shoots from trunks and large branches. Once started, recovery was faster and more encouraging than growers expected.

Newly planted trees that were cut back after the freeze formed very satisfactory new heads and in 1958 these trees showed no evidence of their damage.

Suggestions to Tung Growers

Following are suggestions for emergency care of tung trees following this type of late spring freeze, outlined by ARS scientists.

Cultivation is important to keep grass and weeds from competing for moisture with the belated shoot growth of freeze-damaged trees in May and June. If a winter legume such as crimson clover is grown, cultivation should not start until the seed is mature. Cultivation will be needed to renew the seedbed in the fall. Remove brush from all acreage if possible.

Reduce fertilization, because freeze-damaged tung trees need less than those bearing a full crop. Trees not expected to bear are likely to need about half the normal amount of nitrogen--somewhat more if the trees were starved for nitrogen, somewhat less if the trees were well supplied the previous year or if good clover or other legumes are grown. Omit phosphorus in orchards previously given liberal amounts; otherwise apply 40 pounds of P_2O_5 to the acre. Apply about half the potassium that would have been used if trees were bearing a crop. If mixed fertilizer is used, apply a 10-5-10 mixture, adjusting the amount to provide the minimum normal amount of nitrogen.

Except for the youngest trees, pruning after this kind of freeze is not recommended because wood rot is not a serious tung problem and removing dead wood is expensive. The best procedure is to let the dead wood decay and drop off. ARS scientists who tried pruning 3 year-old trees back to sound wood concluded that the pruning neither speeded nor improved recovery. However, seedlings planted the year before a freeze may require pruning help for a new start if badly injured. Many such trees were cut back to 6 or 8 inches after the 1955 freeze, and low-heading types were trained to a single stem to give them new and well-formed foundation branches. For high-heading types, a better procedure was to cut back to a trunk 12 to 30 inches tall and train to vase form, letting all buds develop.

TAKING A PRACTICAL OUTLOOK

Defense against major freezes cannot be a primary objective in practical orchard management. These freezes are too unpredictable to rate a foremost place in planning. Growers take their strongest precaution against major freeze damage when they keep plantings within the climate areas and sites that have proved suited to the deciduous fruit and nut crops--where these freezes are an unusual hazard.

Knowledge gained from past freezes is mainly useful in dealing with the consequences of the damage. However, some of the findings may be applied to advantage in good all-round orchard programs.

The severe natural tests of major freezes have given valuable evidence on the cold resistance of commercially planted varieties. Such information can be useful in the selection of varieties that combine hardiness with other wanted qualities. The choice of varieties may strengthen orchards against both ordinary and extraordinary cold.

In the case of apples, it has been demonstrated in all the freezes that trees top-worked on hardy trunks and frameworks are less injured than those budded at the ground line.

In irrigated orchards, withholding water in the fall will often result in trees stopping growth earlier and ripening the wood so as to be more resistant to cold injury.

In the aftermath of a major freeze, growers may be saved from some anxiety and loss if they are aware of these facts:

Haste is unwise in dealing with these emergencies. Immediately after a major freeze, it is generally impossible to appraise the damage. Surviving trees may not start natural recovery for weeks but, given time, trees that looked hopeless have been known to prove well worth saving. And in any case, as the outcome becomes clearer, the measures for treating the trees can be more suitably planned and applied.

Although a major freeze injures trees in diverse ways even in the same locality, the damage takes recognizable patterns, which are increasingly evident and which provide guidance in restoring production.

RESEARCH ADVANCEMENT

Research scientists may be expected to continue to advance knowledge for dealing with freeze damage in deciduous orchard trees by such work as this:

- * Further experiments following the emergency of a major freeze to determine how such trees can be handled to promote maximum recovery.
- * Scientific observations on damage and recovery of trees over successive years after a freeze.
- * Research studies on tree physiology, notably metabolic processes, that have a bearing on the effects of cold.

* Further evaluation of the use of hardy kinds of rootstocks and framework varieties for building trees more resistant to cold.

The greatest opportunity for reducing major freeze damage through research is in the development of varieties more resistant to cold, and this is an objective in most fruit and nut breeding programs.